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A REVIEW OF THE UNDERGROUND ENVIRONMENT RESEARCH PROGRAM AT THE ELLIOT LAKE LABORATORY

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ELLIOT LAKE LABORATORY

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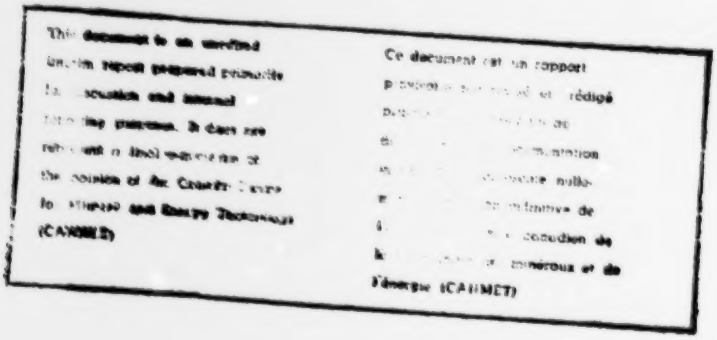

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A REVIEW OF THE UNDERGROUND ENVIRONMENT RESEARCH PROGRAM AT THE ELLIOT LAKE LABORATORY

by

J. Bigu*

ABSTRACT

A review of the research activities of the underground environment group of the Elliot Lake Laboratory since its establishment is presented. The activities of four research groups to the present are discussed: respirable dust, ventilation, radiation, and noise and vibration. The activities of the underground environment are now being more closely coordinated to investigate the impact of all airborne contaminants of mine air on worker's health.

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EXAMEN DU PROGRAMME DE RECHERCHE SUR L'ENVIRONNEMENT SOUTERRAIN AU LABORATOIRE D'ELLIOT LAKE

par

J. Bigu*

RÉSUMÉ

Dans ce rapport l'auteur présente une revue des activités du groupe de recherche sur l'environnement du Laboratoire d'Elliot Lake depuis sa formation. Les activités effectuées à ce jour par quatre groupes de recherche sur la poussière inhalable, la ventilation, les rayonnements, le bruit et les vibrations sont passées en revue. Les activités de recherche sur l'environnement sont actuellement coordonnées de plus près afin d'investiguer les effets des polluants aéroportés en suspension dans l'air des mines sur la santé des travailleurs.

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INTRODUCTION

The Elliot Lake Laboratory was established in 1965 on the Nordic Mine Road, about 10 km south of the town of Elliot Lake on Highway 108. Recently (1985), the Elliot Lake Laboratory was relocated to a new location at 99 Spine Road, about 1 km from the centre of Elliot Lake.

The Elliot Lake Laboratory is part of the Mining Research Laboratories (MRL), a division of the Canada Minerals and Energy Technology (CANMET), which in turn is a branch of Energy, Mines and Resources Canada.

The Elliot Lake Laboratory employs a total of 28 staff members: 13 scientists and engineers; 11 technical support staff; and 4 administrative support staff. A post-doctoral fellow and a visiting scientist are also present.

Initially established as a modest-sized laboratory for research into certain areas related to the mining industry, mainly rock mechanics, the Elliot Lake Laboratory has expanded considerably into other research areas such as tailings, radiation in uranium mines, and other areas relevant to the mining industry.

The main research activities of the Elliot Lake Laboratory can be divided into the three following groups:

1. Rock mechanics;
2. Surface environment; and
3. Underground environment.

In this report, the research activities of the Underground Environment group (CANMET Minerals Program) of the Elliot Lake Laboratory will be reviewed.

RESEARCH ACTIVITIES OF THE UNDERGROUND ENVIRONMENT GROUP

The research activies (project elements) of the underground environment group are divided into the following areas:

1. Respirable dust;
2. Noise and vibration;
3. Radiation; and
4. Ventilation.

In broad terms, the project elements objectives are:

1. To develop instrumentation and to undertake environmental studies related to the above areas to determine contaminant and pollution levels in various mining operations;
2. To develop and evaluate newly developed instrumentation under laboratory-controlled conditions and under field conditions in harsh environments;
3. To identify the major factors affecting the release or generation of contaminants (pollutants), and to investigate the interrelationships between these contaminants in mine environments;
4. To develop control or suppression methods for reducing contaminants (pollutants) levels in mine environments; and
5. to transfer acquired technology to other government agencies, and the mining industry, through reports and publications, meetings, workshops and symposia.

Instrumentation development is mostly done by outside contract to private industry. Most of the other research activities are carried out in-house by the underground environment research staff of the Elliot Lake Laboratory.

The major outputs and research activities of the different underground environment areas are discussed below separately.

RESPIRABLE DUST

The Elliot Lake Laboratory dust research program was initiated to provide a broad data base to help deal with the airborne respirable dust problem in Canadian mines. The dust research program originated in Ottawa (1960), and consisted of compiling dust standards and listing a number of dust sampling instruments used in various industrialized countries.

Shortly after the above work was completed, efforts were aimed at designing a dust chamber to evaluate the performance of dust sampling instruments under laboratory-controlled and simulated underground conditions. In 1965 a dust chamber was set up at the Elliot Lake Laboratory, where it has been used until late 1985 for environmental dust research purposes, and in the technical evaluation of dust sampling instruments. A new dust test facility has recently been designed, presently under contract, which will be installed in the new laboratory in July 1986. It is a dust tunnel rather than a chamber.

The dust chamber permitted a large number and variety of dust samplers to be tested and evaluated. The instrumentation tested included samplers designed to assess dust concentration by number (e.g., konimeters, thermal precipitators and impingers), by light-scattering using infrared (IR) optical systems, and by gravimetric means such as horizontal elutriators and cyclones.

Because of occupational health related issues, airborne quartz dust content determination from dust samplers became a major topic in dust research in 1969 and in subsequent years. A great deal of effort was put into the measurement of quartz by X-ray diffraction (XRD) techniques and from 1969 to 1972 work was aimed at setting up an automated loading/measuring system for quartz analysis in mine dust. By 1972 the XRD system was operational at the Elliot Lake Laboratory. Since then many improvements have been introduced

into the original system, especially in the automation of data acquisition, processing, and analysis by interfacing the XRD system with a computer, and the development of a software package capable of handling the mechanical and electronic operations of the system as well as the complete analysis of the data.

Many field surveys in underground mines have been undertaken since 1970 intended at estimating personal dust exposure, and to investigate (quantify) dust production as related to various mining operations. Extensive field studies have been conducted in underground mines and mills in several Canadian provinces. So far many thousands of samples have been collected and analyzed. The data collected have been published in technical reports, in journals, and have also been presented at meetings and international conferences.

Major in-house development of dust sampling equipment includes a gravimetric sampler, the CAMPEDS, which is a modified version of the SIMPEDS, a British design used in coal mines. Another in-house development is the design of the XRD asbestos sampling head for asbestos sampling. Development of dust sampling instrumentation under contract includes several asbestos/quartz dust automated samplers manufactured by METREX (Toronto), and an optically-based automated submicron/micron airborne particulate sampler developed by Mono Research.

Techniques and methods for the control and suppression of dust emissions have been investigated at the Elliot Lake Laboratory. These include studies on wetting, water sprays, water scrubbers, filtration, electrostatic precipation, and the recent use of a charged water spray system.

The dust research group has been instrumental in technology transfer to industry. The XRD analysis system is now being used by many Canadian mining companies. The CAMPEDS has also resulted in a very valuable gravimetric dust sampler. Significant collaboration has been maintained with a number of

mining companies and research institutions such as Rio Algom, Denison, Quebec Cartier, Eldorado and HBMS in maintaining gravimetric sampling programs and in developing capabilities for XRD analysis. A review of research activities of the dust group has recently been given by Grenier and Bigu elsewhere (1).

RADIATION

The Elliot Lake Laboratory research program was established to carry out research on radiation-related problems relevant to uranium mining and milling, and other uranium related industries.

Effort has been concentrated mainly on airborne radioactive contaminants such as radon gas and its short-lived decay products, a main occupational health concern in the uranium mining industry. Later on, studies on airborne radioactivity have extended to thoron gas and its progeny, a common occurrence in Ontario uranium mines, and to the long-lived radioactivity associated with dust in the respirable size range (1-10 μm).

The main activities of the radiation group of the Elliot Lake Laboratory are summarized below.

1. Area monitoring and personal α-particle dosimetry related to various mining operations, such as leaching, backfilling, fragmentation, and mucking operations.
2. Development of radiation instrumentation and technical evaluation of this instrumentation under laboratory-controlled and field conditions;
3. Mine modelling, i.e., development of radiation/aerosol mine models and radiation/aerosol/ventilation mine models under steady-state and time-dependent conditions;
4. Validation of mine models with experimental data;
5. Studies on radiation control measures and suppression techniques in the laboratory and in underground uranium mines;

6. Radon and thoron progeny studies, in the laboratory and in underground uranium mines, on plate-out phenomena, deposition velocities, attachment rates, attached and unattached fractions and electrical charge;
7. Radon and thoron progeny, and long-lived radioactive dust characterization in uranium mines and mills, i.e., radioisotope identification, concentration and size distribution;
8. Combined studies in underground uranium mines of radiation, ventilation and respirable dust;
9. Development of radon/thoron simulation/test facilities for the calibration of radiation instruments and simulation of uranium mine atmospheres.

Extensive airborne radiation surveys have been conducted since 1978 to estimate radiation levels, personal radiation exposure, and to evaluate radiation instrument performance in underground uranium mines (items 1, 2 and 7). The Elliot Lake Laboratory personal dosimetry program has been quite relevant in Canada and has provided a wealth of data to better assist in the choice of particular dosimeter types for specific field uses. A wide variety of personal dosimeters has been evaluated under field conditions, particularly at Rio Algom Ltd. and Denison Mines Ltd. (Elliot Lake).

A number of environmental monitors and personal dosimeters have been developed under contract over the last eight years. Without exception, all instruments developed are widely recognized in North America and other countries of the world. Over the years, the Elliot Lake Laboratory has also contributed very significantly in providing the technical know-how and expertise to the radiation instrumentation industry for the development of radiation instrumentation. Some of the instruments of international renown developed under CANMET contract and Elliot Lake Laboratory technical expertise are given below:

a) Radon daughter Working Level Monitor, model WL-1000C, by Pylon Electronic Development (Ottawa);

b) Radon daughter continuous Working Level Monitors, models WLM-300 and WLM-30, and radon/radon daughter gas analyzer, model RGA-400, from EDA Instruments (Toronto);

c) Radon daughter/thoron daughter quasi-continuous monitor, model Rn/Tn-750; Rn/Tn passive dosimeter, and personal dosimeter, model alpha-PRISM, by alpha-NUCLEAR (Toronto).

A number of methods and techniques have been investigated in the laboratory for radiation control. These include: filtration, electrostatic precipitation, plate-out in mixing fans, electrostatic screens, and negative ion-generators. Some of these methods and techniques have also been used on a limited scale in the Elliot Lake underground uranium mines on a trial basis. The results from these methods are quite encouraging. Recently, the effect of a charged water spray system on long-lived radioactive dust and radon daughter levels has been investigated. The data are being analyzed at present.

Two radon/thoron test facilities (RTTF) have been designed by the radiation group. A small (3 m^3) chamber has been in operation since early 1982. A large chamber (26 m^3) of the walk-in type was operated during the period 1983-1985. A new RTTF (28 m^3) has been designed which is presently being installed in the new Elliot Lake Laboratory. This RTTF will be the National Test Facility, and has been designed in response to the need for standard atmospheres for radon, thoron and their progeny for the calibration of radiation instrumentation used by industry and some institutions for AECB compliance purposes.

Radiation research at the Elliot Lake Laboratory has been very substantial and has played quite a significant role in CANMET, the uranium mining industry, and radiation instrumentation industry. Numerous papers have

been published and technology transfer to industry has been very substantial. Continuous collaboration with mining companies is actively pursued.

An excellent source of references on the activities of the radiation group can be found in the annual reports of the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada (1979 to 1986) by R. Tervo (2).

VENTILATION

Ventilation is the most common method used to reduce airborne contaminants in working places. The ventilation program at the Elliot Lake Laboratory was established with two main objectives in mind:

1. To carry out ventilation surveys in underground mines in order to estimate friction factors, air residency times, and air flow distributions, and to determine the performance of underground ventilation networks;
2. To develop a computer program which would define the method, quantity and distribution of fresh air in an underground mine in order that:
   a) meteorological conditions such as relative humidity, temperature and air flow are within the limits of reasonable comfort to workers; and
   b) average levels of airborne contaminants are within acceptable limits according to existing standards.

A great deal of work was done in-house and under contract during the period 1977-1981. During the period 1981-1983, personnel responsible for the ventilation program assumed other duties in the rock mechanics group. In 1983, ventilation work was moved to the Mining Research Laboratories (MRL) at the Bells Corners Complex (BCC). Ventilation work at the Elliot Lake Laboratory was initiated again in 1985.

Major studies conducted during 1977-1981 included:

1. Use of sulphur hexafluoride (SF_6) as a tracer gas to estimate mine air residency times using gas chromatographic techniques. These studies included setting up a tracer gas laboratory and extensive work on calibration techniques, and in the sampling and releasing of SF_6 tracer gas;
2. Studies, under contract, to determine ventilation and refrigeration requirements and costs in hard rock mining operations at depths below 200 m;
3. The development of ventilation computer models for deep Canadian mine ventilation networks where compression effects and other phenomena such as moisture lift work, and varying natural ventilation effects are taken into consideration;
4. Some collaborative studies with the radiation and dust group in underground uranium mines.

In addition, some attempts were made to incorporate airborne pollutants into the general description of mine ventilation programs.

In 1985, ventilation work in the Elliot Lake Laboratory was reactivated. Use was made of continuous and pulsed SF_6 gas release techniques to estimate air residency times in a conveyor belt drift and in several stopes. The work was done in collaboration with the Coal Research Laboratory (Cape Breton) using a new gas chromatograph system developed under contract.

Air residency times are also being determined in stopes where bacterial leaching is done in order to estimate oxygen consumption rates. Some mine modelling in dust/ventilation, in particular, is actively pursued at the Elliot Lake Laboratory.

NOISE AND VIBRATION

The objective of the noise and vibration group is to identify major noise and vibration sources and to develop means for maintaining the levels below acceptable thresholds.

The noise and vibration group has been very active ever since its establishment in the 1970's. The major contributions of the noise and vibration program are:

1. Extensive personal noise exposure measurements and field surveys at several mines such as Denison Mines Ltd., Rio Algom Ltd., Falconbridge, and the Saskatchewan Potash Corporation;
2. Studies on a noise monitor hat;
3. Studies, under contract, on the vibration characteristics of mining equipment and the effect of direct vibration on occupational workers;
4. Development of an automated computer-based personal noise dosimeter. A comprehensive software package was written to process and present exposure data. The program includes a statistics package and a graphics package to produce time histories of personal noise exposure; and
5. Extensive studies on noise abatement.

Noise and vibration are rather unique topics in the underground environment in that, strictly speaking, they do not constitute airborne pollutants, and hence, the techniques and methods of control and abatement that must be employed to handle this type of pollution are totally different from the methods used, say, for respirable dust, radiation and noxious gases.

The activities of the noise and vibration program will most probably be phased out by the end of 1986. At present numerous technical reports on the field work conducted in the last 3-years are being prepared for publication.

REMARKS

Several underground field studies by the Elliot Lake Laboratory at the local Elliot Lake uranium mines are in progress.

1. Measurement of air residency times by SF_6 tracer gas and radioactive aerosols techniques in stopes where bacterial leaching operations are currently being carried out. These field studies will provide data to optimize oxygen consumption in the bacterial leaching process. The study is being conducted at Denison Mines Ltd.
2. Evaluation of a water scrubber at a crusher/conveyor belt site to control respirable dust, radioactive aerosol, and long-lived radioactive dust (Rio Algom Ltd.).
3. Evaluation of a charged water spray system to control respirable dust and airborne radioactivity (Rio Algom Ltd.).

As previously indicated, a comprehensive radiation/respirable dust/ventilation program at a crusher/conveyor belt site (Rio Algom Ltd.) was completed in November 1985. The study was conducted to estimate dust production and radiation emissions, and to determine air residency time in the same general area and in several stopes to validate several theoretical mine models, and to evaluate recently developed tracer gas instrumentation.

Frequent collaborative efforts have been made between the Elliot Lake Laboratory and several laboratories of the Mineral Sciences Laboratory (MSL) on dust research related topics, e.g., use of IR techniques for determining quartz dust and studies of wetting agents to reduce airborne respirable dust concentrations, and radiation-related matters, e.g., development of radiation instrumentation for monitoring purposes.

The research activities of the different groups of the underground environment program are now being closely coordinated to investigate the

impact of all the airborne contaminants in mine air of interest, and their interrelationship, on worker's health. Particular attention is being placed on control measures, and in data acquisition and environmental control systems to optimize mining operations and reduce workers exposure risk. A 5-year program with these goals in mind has recently been put forward elsewhere (3).

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